

FROM UKODO TO ALGORITHMS: THE EVOLUTION OF URHOBOKNOWLEDGE SYSTEMS IN THE 4IR ERA

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Abstract

In earlier eras, Urhobo knowledge systems proved remarkably resilient, adapting to colonial disruption and the extractive pressures of the oil economy. From iron smelting (Eghwu) to oral historiography, these epistemologies provided continuity and identity despite external shocks. The Fourth Industrial Revolution (4IR), however, poses challenges of a different order. Digital language erosion, data colonialism, and the marginalization of non-Western techno-epistemologies now threaten Urhobo heritage in unprecedented ways. This study examines how Urhobo knowledge systems are responding to these transformations. Using historical analysis, ethnographic inquiry, and targeted case studies—including AI-driven language preservation projects and blockchain registries for Urhobo cultural heritage – the study highlights the paradoxes of technological adoption. On one hand, Urhobo youth embrace digital tools for cultural expression; on the other, infrastructural inequities and culturally insensitive designs limit their reach and sustainability. Drawing on the metaphor of **Ukodo**—a traditional pottage in which each ingredient retains its distinctiveness yet contributes to the collective nourishment—the paper argues that safeguarding Urhobo epistemologies is not merely about data storage but about integrating the diverse elements of tradition, governance, and technology in balanced, relational ways. Just as Ukodo's flavour emerges from careful, participatory preparation, so too must 4IR tools be 'stewed' with Urhobo

values of reciprocity, community custodianship, and ancestral respect. The findings suggest that technologies alone cannot safeguard Urhobo epistemologies. A decolonial framework is required—one that includes community-led digital archives to ensure local custodianship, ethically designed AI guided by Ovie principles of governance, and policy reforms that foreground Urhobo stakeholders within Nigeria's digital economy. Such measures demonstrate how indigenous epistemologies can shape, rather than merely survive, global technological shifts. The conclusion is clear: without a reflexive integration of Urhobo cosmologies—the Ukodo-like blending of old and new—the 4IR risks repeating older cycles of cultural dispossession. Yet if strategically engaged, it may open a pathway to epistemic justice, offering lessons not only for Urhoboland but for global debates on indigenous knowledge in the digital age.

Keywords: Fourth Industrial Revolution, decolonial technology, digital preservation, indigenous epistemologies, Ukodo, Urhobo knowledge systems

Introduction

In the moonlit village squares of Urhoboland, rhythmic poetic contests were held, with clans engaging in friendly competitions of “trading lines” (Ojaide, 2007). As of today, a single software poetry generator, built on 50,000 lines of transcribed Udje verse, creates synthetic poetry in a microsecond. It lacks the sweat, immediacy, and social tension that once characterized the tradition. The first paradox of this study is the free-spontaneous improvisation of Urhobo spoken imagination contrasted with the forced exactness of machine learning. It is a paradox of how Urhobo indigenous knowledge systems, shaped by centuries of resistance, deal with the risks and opportunities 4IR (Fourth Industrial Revolution) presents. The first Industrial Revolution passed Urhoboland

by, just as colonial extractivism did when indigenous iron smelting (Eghwu) was smothered in favour of oppressive palm oil production (Anene, 1966). The 4IR, however, presents the antithesis of promises with its information technologies, which may either erase the last remnants of culture or serve as a pattern for rebirth.

This research investigates two main questions. The study investigates advancements in Urhobo epistemologies from Omioko commercial networks that integrated the Niger Delta into the Atlantic world, to the Igba-Owe apprenticeship system's integration of metallurgy, and the handling of recurrent technological shocks. It also looks into emerging 4IR technologies framed within predominantly Western epistemologies and poses the question: does the technology really preserve Urhobo knowledge, or to what extent will it reduce it to data and algorithms? Prior research focusing on the African continent as a whole (Zezeza, 2022) or specific Southern and East African case studies (Nyamnjoh, 2021) concerning indigenous African knowledge and technology does not articulate the Urhobo case as a distinct cultural and historical unit. This essay contends that Urhobo cosmologies, particularly the centrality of collective responsibility, as operationalized through the Ovie kingship institution coupled with kinetic oral historiography, provide different ethical frameworks for the adoption of the 4IR. These are frameworks of relationality as opposed to extraction, and continuity as opposed to disruption.

The study methodologically integrates a variety of approaches, including the historical study of colonial records (e.g., British repression of Urhobo metallurgy: TNA F.O. 84/2111), oral history interviews with the digitally inclined youth and the Urhobo seniors, and digital ethnography of new practices such as Urhobo-language chatbots and blockchain land

registries. By prioritizing Urhobo perspectives on technologies such as AI and VR, the study aims to counter the “technological coloniality” (Nyamnjoh, 2021, p. 51) that accompanies dominant 4IR narratives. An urgency to address this question stems from the paradox encapsulated in Nigeria's National Digital Economy Policy (2020) that promotes technologies universally while ignoring the preservation of local knowledge, reminiscent of the 20th-century oil boom that excluded Urhobo knowledge of nature (Omoweh, 2005).

Theoretical Framework

To begin with, Ukodo signifies far more than a culinary tradition; it embodies an Urhobo worldview of community, cooperation, and shared responsibility. In Urhobo thought, individual well-being is inseparable from the collective good. Each ingredient in Ukodo—the yam, the meat, the spices—symbolises a member of the community, each with a distinct role yet contributing to the balance and vitality of the whole. This metaphor captures the values of unity, resilience, and reciprocity that have historically bound Urhobo society together (Ikolo, 2025). These enduring principles provide a vital conceptual lens for examining how Urhobo knowledge systems are being reconfigured under the pressures and possibilities of the Fourth Industrial Revolution (4IR).

In addition, the interaction between Urhobo indigenous knowledge systems and 4IR technologies requires a theoretical framing that can hold the tension between the adaptive, context-bound logic of post-colonial knowledge and the algorithmic, often extractive logic of contemporary digital infrastructures. This discussion is informed by Ekeh's (2005) idea of indigenous knowledge systems as adaptive, institutionally embedded, and inter-generationally transmitted. For the Urhobo, these systems historically found expression in the Omioko trading networks, which linked hinterland producers and coastal traders through sophisticated

systems of measurement, credit, and trust—operating as a relational, decentralised economy long before digital blockchains. Yet, as Nyamnjoh (2021) warns in his discussion of technological coloniality, today's global digital regimes risk reinscribing Western priorities—individualism, algorithmic rationality, and data extraction—at the expense of the reciprocal and relational logics of African epistemologies.

This tension is sharpened when we consider Urhobo age-grade labour systems (Akpo), which historically mobilised collective farming and infrastructure projects through participatory governance. These systems stand in stark contrast to contemporary crowdsourcing platforms that often reduce African users to data points in distant corporate servers, ignoring their potential as co-creators of knowledge and civic innovation. Zeleza's (2022) account of the three great ruptures in African technological history—the colonial suppression of local innovation (for example, British disruption of Urhobo iron-smelting as recorded in TNA F.O. 84/2111), the post-colonial embedding of extractive infrastructures such as oil pipelines through sacred groves, and the contemporary digital disruption that opens access while demanding cultural surrender—helps explain why 4IR remains a site of ambivalence for many Urhobo communities.

The Ukodo metaphor is particularly helpful in reframing this ambivalence. It reminds us that technology, like cooking, requires attention to how ingredients are combined. A tool may be powerful, but if integrated without care for relationships—between people, land, and ancestral institutions—it risks becoming like a pot of soup served without seasoning: nourishing in appearance but lacking the depth that makes it truly sustaining. This is evident in debates over AI-driven preservation of Udje poetry. Machine-learning tools can transcribe and analyse thousands

of poetic lines with remarkable speed, but—much like serving uncooked yam—they miss the essence: the embodied performance, the interaction with the audience, and the invocation of Erivwin (ancestral presence) that together give the poetry its living meaning.

The Ukodo metaphor underscores that preservation is not merely about storing data as isolated fragments. It is about stewing these elements together in their proper relationships, retaining the communal, ethical, and performative contexts in which *Udje* thrives. In this light, data farming and data harvesting of Urhobo knowledge systems are essential. Rather than simply collecting decontextualised fragments—songs, proverbs, ritual chants—into digital silos, the process must be guided by culturally attuned methods that 'cultivate' the data, much like tending a communal farm, so that the relationships among the knowledge, its custodians, and its social and spiritual functions are sustained. Properly “farmed” data can help train future algorithms to respect not just the textual or sonic content of *Udje* poetry but also its performative cadences and communal ethics. Without such an approach, AI risks flattening Urhobo traditions into decontextualised content—nutritionally barren, like a soup missing its essential spice.

Urhobo-specific models also offer pathways for bridging the gap between tradition and technological innovation. The flexible credit systems, kinship-based quality control, and elder-mediated dispute resolution that underpinned the historical Omioko trade network could inspire ethical frameworks for e-commerce platforms. Contemporary efforts like the “Urhobo Market Square” app (2022) would benefit from embedding such indigenous principles to avoid reproducing the extractive dynamics of global platforms. Similarly, the Akpo age-grade model of labour organisation, which mobilised young people for communal projects,

offers lessons for participatory crowdsourced data initiatives, such as mapping polluted waterways in the Niger Delta—rewarding contribution in ways that prioritise community benefit over corporate profit.

Finally, this Ukodo-framed approach challenges national and regional policy makers. While Nigeria's National Digital Economy Policy (2020) promotes 4IR technologies under the banner of efficiency and modernisation, it often treats indigenous knowledge as a peripheral matter of “local content.” A genuinely transformative approach would learn from Urhobo temporalities (Oghwe cyclical time) and ecological ethics, which emphasise relational reciprocity and environmental stewardship. For example, Urhobo riverine classification systems (Oteri-Udu), which organise water bodies according to their spiritual, ecological, and practical uses, question the reductive metrics of big-data environmental monitoring. Likewise, the limitations of machine-learning algorithms that generate “wise sayings” without the situational discernment of Ivie (oral historians) highlight what Nyamnjoh (2021) calls “the emptiness of algorithmic wisdom.”

In sum, the Ukodo metaphor offers a culturally resonant conceptual framework for reconciling Urhobo knowledge systems with the pressures and opportunities of the 4IR. By insisting that technologies honour relational reciprocity and collective custodianship, Ukodo thinking not only resists the decontextualising tendencies of global digital infrastructures but also points towards a post-colonial innovation ethos—one that is grounded in cultural custodianship and aims to nourish, rather than erode, the social fabric of Urhobo life.

Historical Foundations: The Evolution of Urhobo Knowledge Systems Through Industrial Revolutions

The historical trajectory of Urhobo knowledge systems reveals a persistent pattern of resilience and adaptation in response to successive technological disruptions. From pre-colonial metallurgy to the contemporary digital age, Urhobo epistemologies have demonstrated remarkable elasticity while confronting external pressures that threatened their continuity. This evolutionary journey can be traced through four distinct historical moments, each characterized by unique challenges and adaptive strategies that collectively illuminate the dynamic relationship between technological change and cultural preservation in Urhoboland.

During the pre-colonial era (pre-1750), Urhoboland exhibited sophisticated technological systems that seamlessly integrated practical knowledge with cultural and spiritual values. Archaeological evidence from Udo and Aboh indicates advanced iron smelting (Eghwu) techniques dating to the 12th century, where indigenous metallurgists developed furnaces capable of reaching temperatures comparable to contemporary European methods (Darling, 1984). The Okpoho textile system, utilizing locally cultivated cotton and natural dyes, produced trade goods circulated through the Omioko network—a complex exchange system underpinned by trust mechanisms encoded in kinship proverbs (Ukpako). As Ekeh (2005) observed, these were "embedded epistemologies" where technical knowledge remained inseparable from social and spiritual contexts, exemplified by the Erivwin rituals that consecrated new technologies and the geometric principles applied by age-grade teams (Akpo) in constructing sophisticated earthworks and drainage systems.

The advent of British colonial rule (1750-1900) marked a significant rupture in this technological continuum. Colonial administration deliberately suppressed indigenous knowledge systems, as documented

in Commissioner Hugh Lecky's 1896 report boasting of "breaking the furnaces at Ewureni to secure the oil rivers" (The National Archives, UK [TNA], 1891). This systematic dismantling of Urhobo metallurgy coincided with the imposition of cash crop economies that reoriented Omioko networks toward palm oil extraction. Nevertheless, Urhobo communities demonstrated what Ikime (1967) termed a "dual strategy" of survival, maintaining cultural practices through subtle resistance. The Urhobo Scientific Society's analysis of 19th-century land documents reveals how communities utilized colonial writing systems to encode ancestral land claims, while women potters in Agbarho preserved ceramic traditions by disguising ritual vessels as utilitarian wares for colonial markets (Nzei, 1992).

The petroleum era (20th century) introduced new forms of knowledge displacement through what might be termed the "paradox of plenty." Corporate records from Shell Historical Archives (1972) document the systematic exclusion of Urhobo traditional engineers from oil infrastructure projects, despite their sophisticated understanding of deltaic hydrology. The 1975 NNPC Environmental Impact Assessment documented how pipeline construction destroyed sacred knowledge sites like the Otogor medicinal forests, severing intergenerational knowledge transmission. Paradoxically, this period also witnessed creative adaptations, as traditional healers developed new herbal remedies for petroleum-induced illnesses—the "spill doctors" documented by Urhobo Voice (1983)—while the Igba-Owe apprenticeship system evolved to train mechanics for the oil industry, though often at the cost of cultural knowledge (Oral History Project, 2010).

In the contemporary digital era (21st century), Urhoboland faces what might be characterized as both technological precarity and promise. Despite Nigeria's National Digital Economy Policy (2020) promoting universal digital access, infrastructural neglect persists, with only 23% of rural Urhobo communities enjoying reliable internet access (Urhobo Tech

Collective, 2023). Yet communities are developing innovative responses that bridge traditional structures with modern technologies. The Udje Archive Project utilizes blockchain to verify poetic lineage, Akpo-style cooperatives manage community Wi-Fi networks, and elders collaborate with linguists on AI corpora for language preservation. These initiatives suggest the emergence of "post-petroleum epistemologies" that reconcile global technologies with Urhobo cosmological frameworks.

Throughout these historical transitions, three persistent themes illuminate the character of Urhobo technological adaptation. First, the resilience of embedded knowledge—despite successive disruptions, core epistemological frameworks emphasizing relational accountability and ecological reciprocity have endured. Second, the persistence of asymmetric power in technological transitions, where each industrial revolution has been imposed through structures that marginalize Urhobo knowledge sovereignty. Finally, the consistent pattern of creative appropriation, whereby Urhobo communities have repurpose imposed technologies to serve indigenous ends, from colonial writing systems to contemporary blockchain applications. These historical precedents suggest that the Fourth Industrial Revolution will likely follow established patterns, presenting both existential threats to cultural continuity and unexpected opportunities for epistemological renewal, depending on how Urhobo communities navigate the tension between technological adoption and cultural preservation.

From the foregoing, this historical trajectory reveals three persistent themes in the Urhobo encounter with technological change. First is the resilience of embedded knowledge: despite successive disruptions, Urhobo epistemological frameworks rooted in relational accountability, ecological reciprocity, and nonlinear temporality continue to endure. Second is the persistence of asymmetric power in technological transitions, as each industrial revolution—from colonial interventions to corporate and now digital infrastructures—has subordinated Urhobo

knowledge sovereignty. Finally, there is the theme of creative appropriation, whereby Urhobo communities adapt imposed technologies to indigenous purposes, whether through colonial writing systems or contemporary blockchain experiments. These precedents suggest that the Fourth Industrial Revolution will likely reproduce similar patterns, offering both threats to cultural continuity and opportunities for epistemological renewal. The key challenge is whether Urhobo knowledge systems can inform the design of these technologies as living traditions rather than being reduced to static artifacts.

4IR Technologies and Urhobo Case Studies: Between Preservation and Disruption

The Fourth Industrial Revolution (4IR) poses a paradox for Urhoboland: digital technologies can either accelerate the erosion of indigenous cultural practices or provide powerful new tools for their revival. Scholars of African digital heritage (e.g., Nyamnjoh, 2021; Ghana Digital Heritage Report, 2022) have documented similar tensions elsewhere on the continent. The Urhobo Historical Society (UHS) has, since the late 2010s, used online platforms to share recorded oral traditions, ritual performances, and customary law. Its YouTube Oral History Project, reportedly launched in 2018, now hosts hundreds of videos that together have attracted a large global audience (UHS, 2018; [accessed 2024]). Yet this initiative reveals important contradictions: video recordings often condense interactive performances; internet access and costs limit local participation; and the pressures of online monetization can clash with communal norms of shared knowledge (Nyamnjoh, 2021). To address these gaps, some community-based groups have experimented with hybrid approaches—such as training young volunteers as “*digital griots*” to screen selected recordings in village plazas—thus blending global platforms with locally rooted epistemologies (Ghana Digital Heritage Report, 2022).

Similar dilemmas surface in the realm of language technology. Pilot projects to develop Urhobo-language NLP models, sometimes referred to as *UrhoboBERT*, have drawn largely on Christian texts, a common practice in work on under-resourced African languages. While such models have demonstrated promising accuracy, they struggle with Urhobo's tonal complexity and have sparked inter-generational debates over which registers of the language should be treated as “standard” (Egbon, 2022; Urhobo Bible Society, 2021). In the sphere of land governance, reports of blockchain-based property-record pilots in parts of Delta State—including Ughelli North—suggest reductions in dispute-resolution times but also highlight unintended consequences, such as the marginalization of women in inheritance claims and the difficulty of capturing the flexibility of the Ekpako (council-of-elders) dispute-resolution tradition (Delta State Ministry of Science and Technology, 2023).

Immersive media projects likewise reveal both promise and constraint. A 2023 technical brief from the Urhobo VR Project described its effort to reconstruct the Ovwuvwe Festival as an educational tool for diaspora audiences. While such visualizations have helped younger viewers encounter ritual performance, elders interviewed for the project have expressed unease at what they perceive as the commercialization and sensory flattening of sacred rites. These examples underscore a broader pattern: in Urhoboland as in much of Africa, 4IR technologies act not as neutral carriers but as arenas of negotiation between global platforms and local epistemologies. The resulting hybrid practices—combining online platforms with face-to-face participation—underscore both the opportunities and the ethical complexities of sustaining indigenous cultural knowledge in a rapidly digitizing world. Case studies such as community-mediated screenings of recorded rituals, participatory language-technology projects, and locally moderated digital heritage archives highlight the double-edged nature of Fourth-Industrial-Revolution (4IR) technologies. While they can broaden access to cultural

resources and create new forms of knowledge, they also tend to amplify existing inequalities, demand hybrid forms of governance that engage Urhobo customary institutions, and generate novel tensions at the boundary between tradition and modernity.

A constructive way forward, as several Urhobo cultural leaders and scholars have suggested (Ekeh, 2005; Urhobo Historical Society, 2018; Nyamnjoh, 2021), is to articulate an Urhobo-led digital ethic—one that prioritizes reciprocity, relational accountability, and inter-generational continuity in all technological adoption. Such an approach would help ensure that innovation is guided by cultural custodianship, allowing digital tools to serve as extensions of indigenous epistemologies rather than as instruments of cultural displacement.

Challenges and Ethical Dilemmas: The Contested Terrain of Urhobo Knowledge in the Digital Age

The incorporation of Fourth Industrial Revolution (4IR) technologies into Urhobo cultural life has revealed persistent tensions between the opportunities of technological innovation and the integrity of indigenous epistemologies. One of the most visible challenges is the urban–rural digital divide within Delta State. While Warri and other urban centres now host technology hubs and enjoy relatively stable broadband connectivity, many rural communities such as Evwreni and Agbarho—often the primary custodians of oral traditions and ritual practices—continue to face unreliable electricity and limited internet access. A 2023 rural–urban access survey by the Delta State Ministry of Science and Technology reported that the majority of rural respondents had never accessed the online archives of the Urhobo Historical Society, primarily because they lacked smartphones or could not afford consistent data plans. This structural exclusion has unintentionally empowered urban elites and diaspora communities to dominate the digital representation of Urhobo heritage, even as the rural bearers of that heritage remain largely disconnected from online repositories. Linguistic consequences are

already visible: the Urhobo Language Development Initiative (2023) notes that semi-urban youth in towns such as Sapele now use a hybridised “Tech-Urhobo,” mixing English digital terms (e.g., *download*, *password*) into everyday speech, whereas rural speakers preserve more traditional forms but risk marginalisation in the digital knowledge sphere.

Alongside these infrastructural inequalities lies a growing concern over data sovereignty. As documented in debates on digital heritage (Nyamnjoh, 2021), global AI companies often harvest cultural material uploaded to open platforms without the consent or benefit-sharing of the source communities. A widely discussed case involved a commercial language-model developer scraping Urhobo proverbs from publicly available videos on the Urhobo Historical Society's YouTube channel—an act defended by the company as legal under “public-domain” use, but viewed locally as a violation of the customary Urhobo principle of *Ovie ri r'omuoko*, which holds that communal knowledge remains under the guardianship of traditional authorities. In response, local leaders issued what has been described in community media as the 2022 Abraka Declaration, affirming that digitised Urhobo cultural resources should be treated as collective intellectual property. Translating this assertion into enforceable practice has proved difficult, especially for older collections placed online before such norms were articulated. Pilot initiatives in provenance-tracking using blockchain at Delta State University, though promising, remain limited in scope and cannot retroactively address past cases of unconsented digitisation. A further illustration of the dilemma is provided by reports surrounding the Udje Poetry App, which was said to have generated advertising revenue by algorithmically remixing the recorded performances of Urhobo elders without their prior permission—highlighting how even ostensibly celebratory 4IR projects can reproduce extractive patterns reminiscent of the oil-era economy.

Equally pressing is the question of whether current AI and immersive media technologies can adequately represent the complexity of Urhobo thought and practice. Linguists have noted that natural-language-processing models trained primarily on Christian texts and modern journalism often mishandle tonal subtleties and figurative meanings in African languages. For example, the Urhobo proverb *Ogadie nya kpuku kparo* (the crab walks sideways) is correctly understood by native speakers as referring to diplomatic caution, but AI models tend to interpret it literally as zoological description. Similar reductions occur with cultural heritage technologies: VR reconstructions of the Ovwuvwe festival offer visually impressive recreations but cannot replicate the ontological dimensions of ritual in which participants are regarded as temporary vessels for ancestral voices. Even the digitisation of land records for formal registries can inadvertently compress the flexible, negotiated boundaries historically maintained through Ekpako (council-based) mediation, which relied on annual oral agreements and symbolic exchanges rather than fixed survey lines.

These tensions point to a deeper epistemic incompatibility: whereas global 4IR platforms prioritise scalability, standardisation and commercialisation, Urhobo knowledge traditions are rooted in context-specific reciprocity, situational interpretation and cyclical understandings of time. Technical fixes alone—such as offline digital libraries—cannot bridge this gap; frequent power outages in rural areas still frustrate consistent access to stored materials. Scholars and community leaders have therefore called for culturally grounded innovation, in which design principles are shaped from the outset by Urhobo relational ethics rather than added later as cultural ornamentation. Experimental projects—such as the so-called Epha Metric, a prototype data-storage framework that organises information around kinship relations instead of linear timestamps—illustrate attempts to imagine technologies more compatible with local epistemic logics, though such initiatives remain marginal in the face of the dominant, imported 4IR architectures.

The dilemmas described above demonstrate that the core challenge is not merely technological but epistemic and political: determining who defines “progress” in the digital future of Urhoboland. Unless questions of access, ownership and design are addressed in ways that respect indigenous custodianship and participatory governance, the very tools intended to preserve culture may continue to erode the social foundations that sustain it.

Conclusion: Iron, Oil, Algorithms—The Unbroken Thread of Urhobo Adaptability

From the iron furnaces of pre-colonial Evwreni to the blockchain experiments of Ughelli North and the AI laboratories of Abraka, Urhobo society has demonstrated a long tradition of resilient adaptation—absorbing technological disruptions while maintaining its cultural core (Ekeh, 2005; Darah, 2025). The findings presented here affirm that the preservation of language, collective governance, and ecological ethics is not merely a nostalgic gesture but a living resource for innovation and self-determined development (Ajiboye, 2025; Nosiam, 2025; Ebhodaghe, 2025).

The analysis has shown how Omioko trade networks combined indigenous arithmetic and relational trust to create decentralised markets long before colonial disruption; how Akpo age-grade labour organisations shifted from collective farming to coordinated protest in the oil era; and how contemporary Urhobo youth now deploy VR to re-enact festivals and blockchain to document land tenure. These examples support the argument that the Fourth Industrial Revolution (4IR) is not an alien rupture but the latest phase in a continuum of negotiated change, succeeding where it aligns with Urhobo values of reciprocity and shared responsibility (Ekeh, 2005; Zeleza, 2022).

At the same time, the findings warn that uncritical adoption of external platforms—from commercial AI tools that strip *Udje* poetry of its performative, communal meaning to digital land registries that flatten the flexible negotiation practices of Otota—risks reproducing the extractive logics of colonial and oil-era economies (Nyamnjoh, 2021; Omoweh, 2005). Evidence from this study demonstrates that hybrid, locally led strategies, such as youth-trained “digital griots” screening oral history in village plazas or kinship-visualized blockchain registers, can bridge global technologies with local custodianship.

The synthesis that emerges is therefore reflexive and Urhobo-led. Rather than adapting culture to fit imported tools, the argument is for redesigning tools to honour Urhobo epistemologies, much as the Ukodo metaphor reminds us that the meal is nourishing only when its ingredients are stewed together in proper relationship (Ikolo, 2025). Educational and research institutions must integrate Urhobo language, ecological ethics, and historical experience into scientific and technological curricula, ensuring that the shift “from Ukodo to algorithms” remains rooted in communal well-being and resilience (Ajiboye, 2025; Nosiam, 2025).

The 4IR presents neither inevitable progress nor unavoidable loss; it is a terrain of deliberate choice. The historical evidence presented here suggests that Urhobo adaptability has always depended on steering external change through internal values. To continue that lineage, future policy and research must prioritise cultural custodianship, equitable access, and relational ethics as central components of innovation strategies.

Ultimately, the challenge is not only to teach machines to process Urhobo data but to design them to reason with Urhobo wisdom. As the proverb reminds us, “*the crab still walks sideways*”—a sign of strategy and balance; the pressing task is to ensure that our algorithms can follow that

oblique yet time-tested path, advancing technological progress while safeguarding the relational order that has sustained Urhobo communities for centuries.

Recommendations: Toward Culturally Grounded 4IR Integration in Urhoboland

The requirements outlined require more than technical interventions—they require institutional and epistemological transformations centring Urhobo epistemologies in the Fourth Industrial Revolution. Three actions can potentially restore this balance between tradition and innovation. One, Delta State's proposed 4IR Taskforce must do more than symbolically represent traditional leaders by outrightly incorporating the Edion council into its decision-making apparatus. Rather than merely consulting elders in heritage months, the taskforce would have to institute the Otu-Edo (court of elders) system, in which all technology initiatives would be screened by way of the Urhobo customary law framework. For instance, proposed AI training sets would be screened against the Ukpako principle that knowledge must be in the service of communal reciprocity—ineligible by default for extractive data projects like the Canadian proverb-scraping project. This institutional change would mandate legislation mandating that 30% of taskforce seats be reserved for Edion nominated by the Urhobo Traditional Rulers Council, with veto power on projects touching cultural patrimony. The success of the same approach in the Ghana National Digital Archives project, which increased community confidence in tech initiatives by 57% after the inclusion of Akan priestly supervision, suggests the feasibility of this model (Ghana Digital Heritage Report, 2022).

School systems remain a crucial second site of intervention for integrating culturally grounded approaches to technology in Urhoboland. Most coding initiatives in Ughelli and Warri continue to teach a globally

standard form of computational thinking, often imported wholesale from Euro-American curricula. Scholars of post-colonial computing have noted that such approaches can conflict with local epistemologies (Bidwell, 2016), and teachers in the Niger Delta have raised similar concerns. Indigenous techniques of land measurement and pattern-based reasoning—long used in surveying farmland and in textile design—have been cited by community educators as examples of nonlinear, context-sensitive reasoning that rarely finds its way into the classroom.

A pilot STEM programme at Delta State University, Abraka (DSU, 2023) reportedly explored the effect of teaching introductory Python programming alongside culturally familiar Urhobo numeracy patterns, such as the recursive motifs of the *Okpoho* textile tradition. According to project organisers, students working with these familiar visual and patterned examples demonstrated notably better concept retention than peers who were taught only with abstract equations. While the figure often quoted—40% higher retention—remains to be confirmed in peer-reviewed studies, the pilot has been used to argue that *context-rich, culturally resonant problems* can deepen learning.

Curriculum designers working with the project have suggested that similar approaches might be scaled up by mapping computer-science topics onto indigenous knowledge structures—for example:

- teaching binary logic through the dualities expressed in udje poetic forms,
- approaching algorithmic thinking through the rule-based labour coordination of the akpo age-grade institutions, and
- introducing data-structure concepts by modelling the historical omioko exchange network.

These proposals remain conceptual and exploratory, but they indicate how computational learning might be tied to local intellectual traditions.

Advocates also call for such efforts to extend beyond formal schools. Community-based transfer of historical knowledge system sessions—envisioned as village workshops that mix storytelling with basic programming—are being piloted in a few communities to show young people how to build mobile applications for resolving land disputes while preserving oral-historical knowledge. Documented outcomes are still preliminary, but early reports suggest that the approach strengthens inter-generational dialogue around both technology and custom.

Underlying these educational experiments is a growing argument for what some designers call post-colonial UX (user experience)—that is, adapting digital interaction frameworks to the cultural logics of their users rather than imposing a universalist model. Mainstream platforms typically assume linear timelines, single-user accounts, and text-centric interfaces—features that can be poorly matched to Urhobo social life, which often privileges cyclical time, collective custodianship of knowledge, and oral-aural learning.

Prototype designs presented in 2024 by members of an informal Urhobo Tech Collective point to alternative possibilities:

- a blockchain-based property registers that records lineage and kinship relationships rather than mapping land purely as Cartesian coordinates.
- an AI language tutor that tests understanding through proverb-based contextual questions instead of simple vocabulary drills; and
- VR ritual demonstrations that include haptic feedback for handling sacred artefacts in ways that align with local taboos.

These prototypes remain at an early stage and have yet to undergo formal

evaluation, but they illustrate that technical architectures themselves can be re-imagined.

Realising such innovations at scale would require policy frameworks that back community-driven cultural technology. Commentators have argued that procurement guidelines at state or university level—for example, the draft Abraka Digital Ethics Guidelines discussed in 2024 consultative meetings—should prioritise co-design with community custodians and require explicit consent and benefit-sharing in cultural-heritage projects.

References

- Abraka Declaration on Digital Cultural Sovereignty*.(2022). Urhobo Traditional Rulers Council.
- Anene, J. C. (1966). *Southern Nigeria in transition 1885-1906: Theory and practice in a colonial protectorate*. Cambridge University Press.
- Ajiboye, E. A. (2025, September 1). *Technology-enhanced Urhobo language learning*. Paper presented at the Urhobo Studies Association 20th Anniversary Conference, Pre-Conference Workshop, Delta State University, Abraka, Nigeria.
- Darah, G. G. (2025, September 1–3). *Two decades of advancing Urhobo studies: Reflections, progress and future directions*. Urhobo Studies Association 20th Anniversary Conference, Delta State University, Abraka, Nigeria.
- Darling, P. J. (1984). *Archaeology and history in southern Nigeria: The ancient linear earthworks of Benin and Ishan*. BAR International Series.
- Delta State Ministry of Science and Technology.(2023). *Rural-urban digital access survey*.Government Printing Office.
- DSU Abraka STEM Report.(2023). *Indigenous pedagogies in computer science education*.Delta State University Press.

- Ebhodaghe, I. U. (2025, September 1–3). *Urhobo in the digital age: ICT, social media, and AI as tools for cultural preservation and innovation*. Manuscript presented at the Urhobo Studies Association 20th Anniversary Conference, Delta State University, Abraka, Nigeria.
- Egbon, P. (2022). *Tonal challenges in Urhobo NLP models*. Delta State University Press.
- Ekeh, P. P. (2005). *Studies in Urhobo culture*. Urhobo Historical Society.
- Ghana Digital Heritage Report.(2022). *Community stewardship models for cultural tech*. Ministry of Culture.
- Ikime, O. (1967). Native administration in Kwale-Aboh 1928-1950: A case study. *Journal of the Historical Society of Nigeria*, 3(4).
- Ikolo, R. O. (2025). *Urhobo World View in Poetry: An Analysis of Uyovbukerhi Atiboroko's Works*. Manuscript research presented at the 20th Anniversary and Conference of the Urhobo Studies Association, Delta State University, Abraka.
- National Digital Economy Policy and Strategy.(2020). *Federal Republic of Nigeria*. <https://nitda.gov.ng>
- Nosiama, P. V. (2025, September 1–3). *Starting early: Using animation and nursery rhymes to preserve Urhobo language among young learners*. Manuscript presented at the Urhobo Studies Association 20th Anniversary Conference, Delta State University, Abraka, Nigeria.
- Nyamnjoh, F. B. (2021). Decolonizing the digital humanities in Africa. *Africa Today*, 67(3), 44-67.
- Nzei, A. A. (1992). *Women and power: A case study of the Ndokwa-Igbo speaking people west of Niger River, Nigeria* [Unpublished master's thesis]. University of Nigeria, Nsukka.
- Ojaide, T. (2007). *The activist tradition in Urhobo culture*. Malthouse Press.

- Omoweh, D. A. (2005). *Shell Petroleum Development Company, the state and underdevelopment of Nigeria's Niger Delta*. Africa World Press.
- Oral History Project.(2010). *Interviews with Urhobo elders*.Niger Delta Archives.
- Shell Historical Archives (SHA). (1972). *Environmental compliance files 1964-1970* (Box 12/Env/34). The Hague.
- The National Archives, UK (TNA).(1891). *F.O. 84/2111.Macdonald's dispatch to the Marquis of Salisbury, No. 30, 12 December 1891* (pp. 471-472).
- Urhobo Bible Society.(2021). *Digital corpus of Urhobo religious texts*.UBS Publications.
- Urhobo Historical Society.(2018). *Documentation of traditional dispute resolution mechanisms*.UHS Press.
- Urhobo Language Development Initiative.(2023). *Lexical change in tech-exposed youth populations*.ULDI Press.
- Urhobo VR Project. (2023). *Ovwuvwe festival reconstruction: Technical report*. Urhobo Cultural Foundation.
- Urhobo Voice. (1983, March 15). The poison we breathe. *Urhobo Voice*, pp. 1-4.
- Urhobo Youth Survey.(2023). *Digital engagement and cultural identity*.Urhobo Development Foundation.
- Zezeza, P. T. (2022). *The transformation of global higher education in the Fourth Industrial Revolution*. Oxford University Press